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IMMATURE STAGES OF *OXYPORUS JAPONICUS* SHARP (COLEOPTERA: STAPHYLINIDAE: OXYPORINAE), WITH NOTES ON PATTERNS OF HOST USE

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Abstract.—Eggs, larvae, and pupae of Oriental species *Oxyporus japonicus* Sharp are described and illustrated based upon field collected and laboratory reared material. Known aspects of the life history and habits of *O. japonicus* are also described. Adults are known to feed on mature basidiocarps of various fungi, including *Pleurotus ostreatus* (Fries) Kummer, *Lampteromyces japonicus* Singer, *Armillaria mellea* (Vahl ex Fries) Karsten, *Panellus serotinus* (Fries) Kühner, and *Pholiota lenta* (Fries) Singer. Morphological comparisons of larval instar III are made to *O. stygicus* Gravenhorst. *Oxyporus japonicus* is hypothesized to exhibit a pattern of overall host selection that is relatively narrow with a well defined subset of preference, which is similar to numerous New World species of *Oxyporus*, including *O. stygicus*.

Key Words.—Insecta, Coleoptera, Staphylinidae, Oxyporinae, *Oxyporus japonicus*, mycophagy, fungus feeding, immature stages, behavior.

All members of the staphylinid subfamily Oxyporinae are included in the single genus *Oxyporus* Fabr., a primarily holarctic genus with most species-level diversity in the Nearctic and Oriental regions. Species of *Oxyporus* are obligate inhabitants of higher fleshy mushrooms (Ashe 1984; Leschen & Allen 1988; Hanley & Goodrich 1994a, b, 1995), even though they are typically placed within the staphylinine lineage of staphylinid subfamilies whose members are mostly predatory and use extra-oral digestion (Lawrence & Newton 1982). Adults and larvae burrow into and feed on the tertiary mycelia, pileus, and stipe tissue of mushrooms using various modifications of the mandibles, labial palpi, maxillae, and labrum (Hanley & Goodrich 1995). The fleshy mushrooms that serve as hosts for *Oxyporus* are members of only three orders within the class Hymenomycetes: Agaricales (the gilled mushrooms), Boletales (the bolete mushrooms), and Polyporales (the polypore mushrooms) (Hanley & Goodrich 1995).

Adults of *Oxyporus* are characterized by a large prognathous head with large mandibles and the apically expanded terminal segments of the labial palpi (Fig. 1). Larvae have a distinctive trilobed mala and stout mandibles that are deeply bifid. Both adults and larvae feed by slicing off bits of host fungi and saturating the fungal chunks with preoral digestive fluid (Newton 1984, Leschen & Allen 1988, Hanley & Goodrich 1995). Contrary to what was once thought, adults and larvae are not known to use their prominent mouthparts in a predatory manner.

The immatures of only 7 of the 90 described species of *Oxyporus* are known (Paulian 1941, McCabe & Teale 1981, Leschen & Allen 1988, Frank 1991, Hanley & Goodrich 1994a, Goodrich & Hanley 1995), and none are known for any of the Oriental species. This study describes the immature stages and life history of *O. japonicus* Sharp, a common Oriental species. Patterns of host use and other phenomena, which could be of evolutionary or taxonomic significance, are discussed.

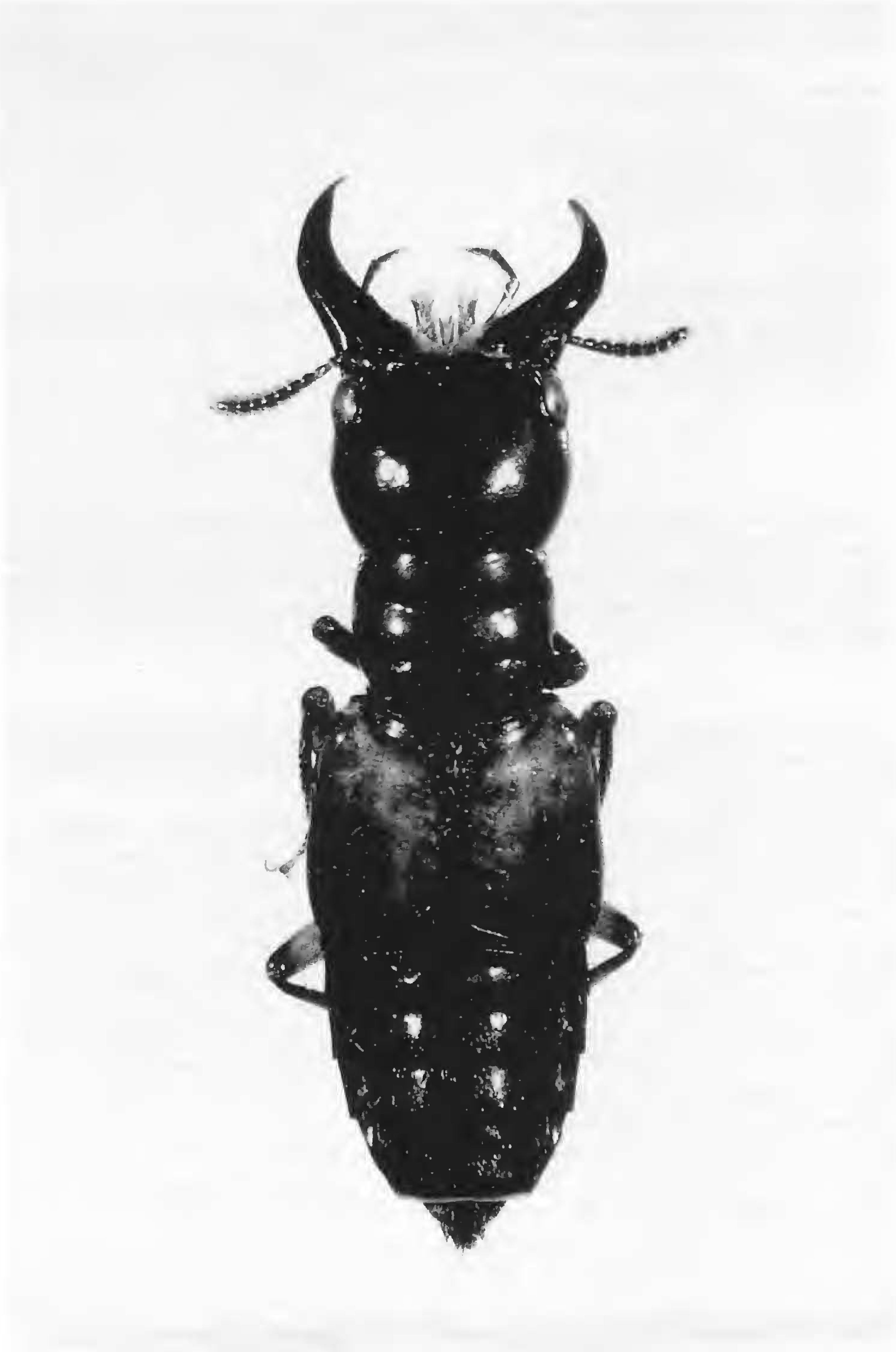


Figure 1. *Oxyporus japonicus* Sharp, adult, dorsal habitus.

Table 1. Known fungal hosts of *Oxyporus japonicus* Sharp.

Host	Number of collections	Number of specimens taken
Tricholomataceae		
Armillaria mellea (Vahl ex Fries) Karsten	2	2
Lampteromyces japonicus Singer[1]	8	1106*
Panellus serotinus[2] (Fries) Kühner	1	8
Pleurotus ostreatus (Fries) Kummer	2	7
Cortinariaceae		
Pholiota lenta (Fries) Singer	1	2

* Includes adults and immatures.
[1] Six records reported by Setsuda (1993, 1994a).
[2] One record reported by Suzuki (1986).

Materials and Methods

Descriptions of the immature stages of *O. japonicus* are based on 51 eggs, 116 larvae (36 instar I, 52 instar II, and 28 instar III), and 2 pupae. The chaetotaxy used in the description of the immatures of *O. japonicus* is based on the system used by Hanley & Goodrich (1994a) in the description of the immatures of *O. stygicus* Say.

Results

Host Relationships.—Adults of *O. japonicus* were found on five fungal hosts from 3 families of fungi (Table 1), but larvae were found only on *Lampteromyces japonicus* Singer.

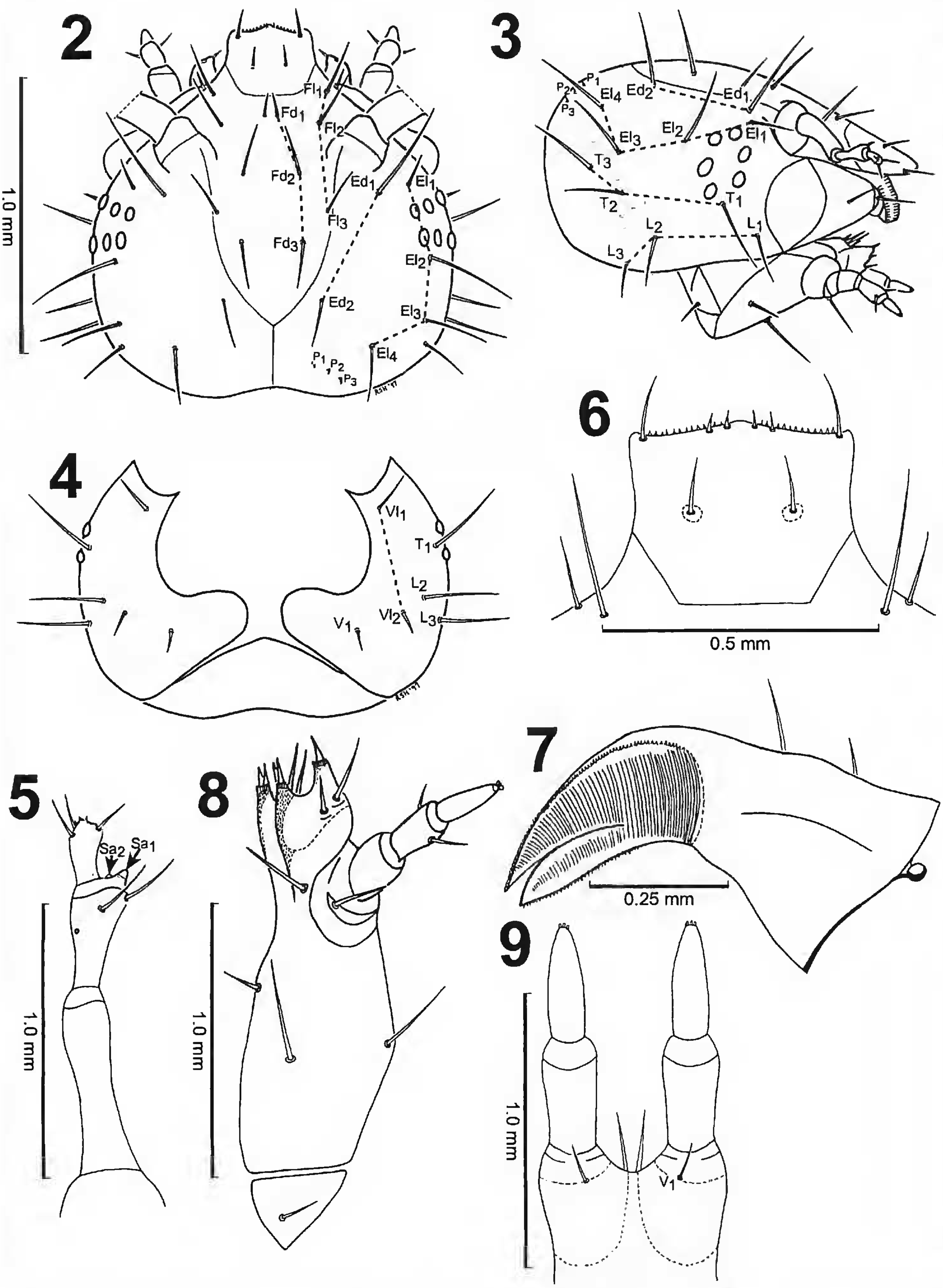
Behavior.—Females of *O. japonicus* were found within cylindrical tunnels extending from an opening on the undersurface of the fungal cap into the center of the basidiocarp of *L. japonicus*. These tunnels likely serve as feeding chambers for both adults and larvae. An enlarged chamber was typically found at the apical end of each tunnel within the stipe tissue of young mushroom fruiting bodies. Within this chamber, eggs were usually found covered with fungal frass. Females remained within their egg chambers after oviposition and repelled conspecific female adults and other predacious beetles before and after the eggs hatched. This behavior has been regarded as subsocial (Setsuda 1994b). Males were less frequently collected within the basidiocarps, but were present. Similar behavior has been reported for some North American species: *O. occipitalis* Fauvel (Hanley & Goodrich 1993), *O. stygicus* (Hanley & Goodrich 1994a, b), and *O. major* Gravenhorst (Goodrich & Hanley 1995). *Oxyporus japonicus,* however, is the first species in which subsocial behavior has been adequately quantified.

Development.—The rapid development of species of *Oxyporus* is well known, and *O. japonicus* fits previously reported patterns. In *O. stygicus* the developmental time from egg to adult was 16–18 days, with 7–10 days in the pupal stage (Hanley & Goodrich 1994a); in *O. major* developmental time was even more rapid (13–15 days) (Goodrich & Hanley 1995). Development of *O. japonicus* from egg to pupa required 12–13 days at room temperature (22–24°C), slightly longer than for *O. stygicus* and *O. major.*

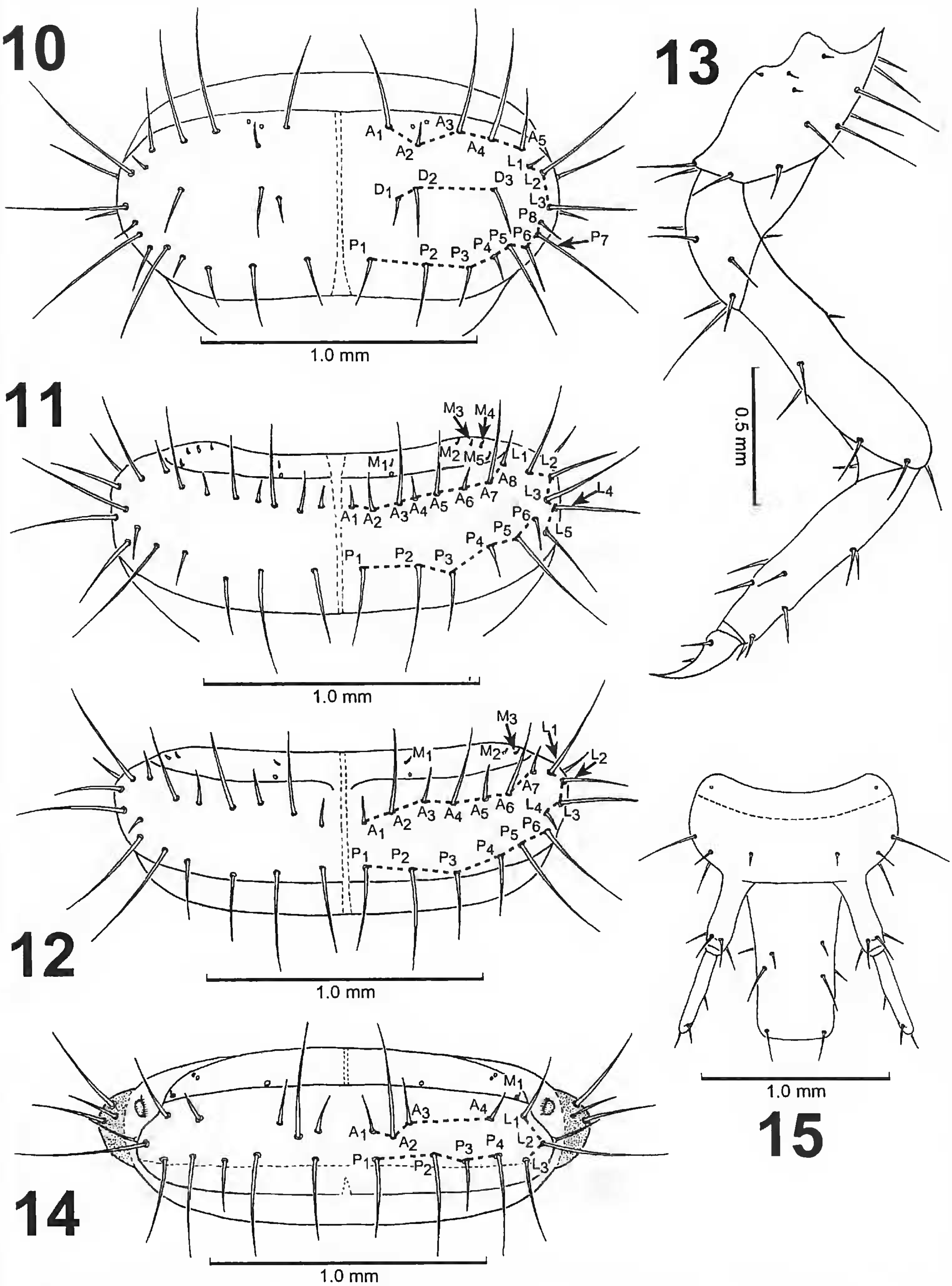
Immature Stages of *Oxyporus japonicus*

Description of Egg.—Length 1.2–1.7 mm; white, darkening with age; cylindrical without distinct sculpture; mouthparts and appendages visible through chorion in more mature eggs.

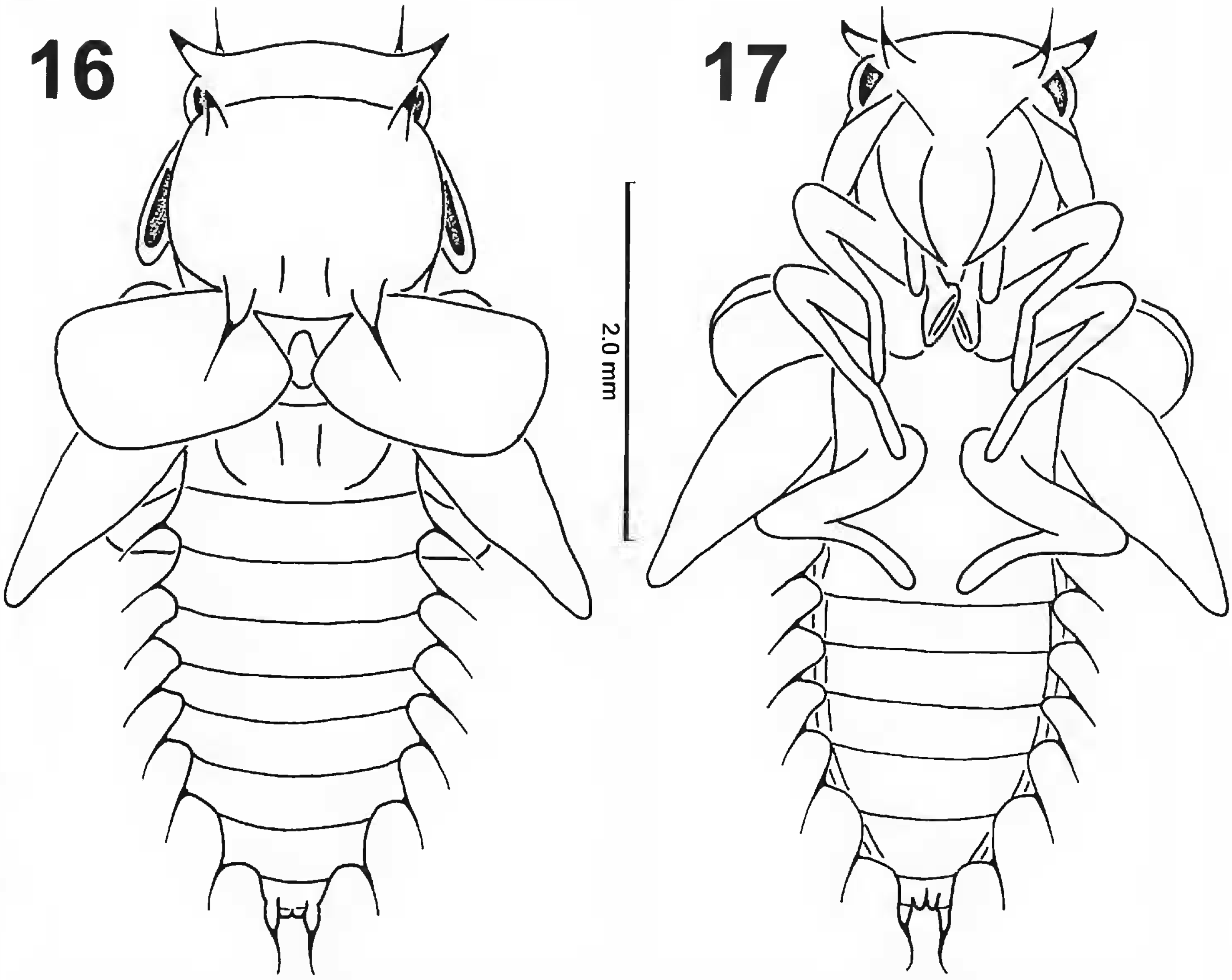
Description of Larval Instar III.—Length 8.8–12.0 mm. Body elongate, gently curved, parallel-sided, slightly flattened dorsoventrally. White with thoracic and abdominal terga brown; head dark yellow to brown. Vestiture length variable, setae simple. Head cylindrical to oval; ecdysial lines distinct, lateral arms forked, complete from back of head to bases of antennae; six pigmented stemmata in two vertical rows on each side (Fig. 2); setal arrangement as in Figs. 2–4. Antenna 3-segmented and inserted anterodorsally near ocelli in membranous socket; segment I elongate, narrowed toward middle, asetose, length 5× width; segment II trisetose, 0.6× length of segment I, bearing tubercle-like sensory appendage with distinct basal collar, single narrower, conical sensory appendage also present; segment III 0.6× length of segment II, bearing inner circle of 3 small, subequal setae at apex, surrounded by outer circle of 3 longer setae (Fig. 5). Labrum fused to frons with anterior margin serrate; chaetotaxy with labral marginal and labral lateral rows of 2 setae each (Ll_2 positioned near Fl_2), labral dorsal row of 1 seta (Fig. 6). Adoral surface of labrum (epipharynx) with numerous branched microtrichia and a large median furrow. Mandibles broad, flat, bifid apically, stout basally; margins finely serrate with many fine teeth, lateral margin with 2 small setae, prostheca absent (Fig. 7). Maxilla with cardo triangular, fused to stipes and mala, with 1 small seta; mala short, stout, trilobed, inner lobe with 2 non-articulated and 2 articulated spines, middle lobe with 2 non-articulated spines and no articulated spines, outer lobe with 1 non-articulated and 2 articulated spines dorsally (Fig. 8). Maxillary palpus 3 segmented; segment I asetose, about as long as wide; segment II bisetose, segment III conical, asetose, length 1.3× length of segment II, minute sensory structures at apex (Fig. 8). Labium of diamond-shaped submentum and trapezoidal mentum, ligula absent; labial palpus 2 segmented, directed ventrally; segment I subequal to length of segment II; segment II elongate and conical with 3 very minute setae at apex; palpigers fused to form ventral premental sclerite, bearing 1 pair setae, no campaniform sensilla present (Fig. 9). Thorax. Pronotum transverse, broadly oval, moderately sclerotized; chaetotaxy with anterior row of 7 setae, discal row with 3 setae, lateral row of 4 setae each, posterior row of 5 setae (Fig. 10). Mesonotum transverse, moderately sclerotized; chaetotaxy with anterior row of 8 setae, posterior row of 6 setae, lateral row of 5 setae, membrane with 5 setae (Fig. 11). Metanotum transverse; chaetotaxy similar to mesonotum, except anterior row of 7 setae, and membrane with 3 setae (Fig. 12). Legs long, each similar in size and configuration; chaetotaxy with 14 setae on coxa, 7 setae on trochanter, 7 setae on femur, 8 setae on tibia, 2 setae on tarsus (Fig. 13). Abdomen. Tergum I transverse, chaetotaxy with anterior and posterior rows of 4 setae each, lateral row of 3 setae, laterotergite with 3 setae each, 1 minute marginal seta present (Fig. 14); tergites and sternites of segments II–VIII similar in setation. Tergite IX with 4 pairs of setae, 1 pair minute campaniform sensilla on disc (Fig. 15). Urogomphi 2 segmented; basal segment fused to tergum IX, with 4 setae on apical half; segment II with 1 small ventral seta



Figures 2–9. *Oxyporus japonicus* Sharp, larval instar III. 2. Head, dorsal aspect. 3. Head, lateral aspect. 4. Head, ventral aspect. 5. Antenna, ventral aspect. 6. Labrum, dorsal aspect. 7. Mandible, dorsal view. 8. Maxilla, dorsal view. 9. Labium, ventral view. Abbreviations: Ed, epicranial dorsal setae; El, epicranial lateral setae; Fd, frontal dorsal setae; Fl, frontal lateral setae; P, posterior epicranial suture; Sa, sensory appendages; T, temporal setae; L, lateral setae; V, ventral setae; Vl, ventral lateral setae.



Figures 10–15. *Oxyporus japonicus* Sharp, larval instar III. 10. Pronotum. 11. Mesonotum. 12. Metanotum. 13. Prothoracic leg, anterior aspect. 14. Abdominal tergum I. 15. Abdominal terga IX–X. Abbreviations: A, anterior setae; L, lateral setae; M, marginal setae; P, posterior setae.



Figures 16–17. *Oxyporus japonicus* Sharp, pupa. 16. Dorsal aspect. 17. Ventral aspect.

and 2 small apical setae (Fig. 15). Abdominal segment X slightly tapered from base to apex, setation composed of 8 setae (Fig. 15).

Variation in Larval Instars.—Overall body lengths of each instar are as follows: instar I, 1.5–2.5 mm; instar II, 3.5–6.0 mm; instar III, 8.5–12.0 mm. Structurally, the first instar differs from the second and third as follows: antennae much shorter and more robust, general reduction in setation over entire body, urogomphi and abdominal segment X much shorter and more robust. The second instar differs from the third as follows: antennae much shorter and more robust, a short Ed_3 seta is present on the dorsal surface of the head, general reduction in the number of setae on the dorsal surface of the thorax, legs shorter and more robust, urogomphi shorter and more robust.

Description of Pupa.—Length 5.5–10.0 mm, white, exarate; with 12 pairs nonarticulated projections on head, prothorax, and abdominal areas. Head positioned ventrally, not completely visible in dorsal view, bearing 2 pairs projections above each eye and no setae on the eyes. Pronotum bearing 2 prominant setae on anterior angles, and 2 large setae off midline along posterior margin. Abdominal segments II-VIII bearing elongate projections along lateral margins; segment IX tapered apically; segment X bearing 2 elongate projections and 2 cylindrical inner lobes (Figs. 16 and 17).

Material Examined.—JAPAN. *Kyoto,* Asyû, 15 Oct 1993 and 19 Oct 1993. K. Setsuda, from *Lampteromyces japonicus* on dead *Fagus crenata* (51 eggs, 36 first instar larvae, 52 second instar larvae, and 28 third instar larvae). JAPAN. *Kyoto,* Miyama, Asyû, 30 Oct 1995, K. Setsuda, from *L. japonicus* (2 pupae). Total number examined, 169 specimens.

Comments.—The mature larva of *O. japonicus* is similar to that of other described species of *Oxyporus,* including *O. vittatus* Gravenhorst (Leschen & Allen 1988), *O. stygicus* (Hanley & Goodrich 1994a), and *O. major* (Goodrich & Hanley, 1995). Larval instar III of *O. japonicus* can be differentiated from the previous species through the combination of the following: 2 setae in epicranial dorsal (Ed) row on head, 5 setae in anterior (A) row on pronotum, 8 setae in anterior (A) row on mesonotum.

Discussion

Immature Stages.—Larval instar III of *O. japonicus* differs from *O. stygicus* in the following ways:

Oxyporus japonicus	*Oxyporus stygicus*
Lateral head seta L_4 absent.	Lateral head seta L_4 present.
2 setae in epicranial dorsal (Ed) row on head.	3 setae in epicranial dorsal (Ed) row on head.
3 setae in temporal (T) row on head.	4 setae in temporal (T) row on head.
3 setae in lateral (L) row on head.	4 setae in lateral (L) row on head.
5 setae in anterior (A) row on pronotum.	3 setae in anterior (A) row on pronotum.
8 setae in posterior (P) row on pronotum.	3 setae in posterior (P) row on pronotum.
8 setae in anterior (A) row on mesonotum.	5 setae in anterior (A) row on mesonotum.

Host Relationships.—Hanley & Goodrich (1995) reported five patterns of host usage in New World *Oxyporus* based primarily on distributions of adults among available host mushrooms: 1) overall host selection broad (7 or more families) with a moderately broad subset of preference (majority of specimens are taken from about half of the total number of genera), 2) overall host selection moderately broad (many genera from 4–6 families) with a relatively narrow subset of preference (majority of specimens are taken from less than one third of the total number of genera), 3) overall host selection relatively narrow (few genera from 2–4 families) with a well defined subset of preference (1–2 genera), 4) overall host selection relatively narrow (few genera from 2–4 families) with no defined subset of preference, and 5) host selection is species specific. Based on the available host records, we hypothesize that *O. japonicus* fits into pattern 3. Adults are found on few genera of fungi, typically two to four families with a noticeable preference towards one or two genera. For *O. japonicus,* 1125 specimens were collected from 5 genera in 2 families of fungi. The vast majority of those specimens, 1106 (98%), were collected from the genus *Lampteromyces.* New World species of *Oxyporus* that exhibit this pattern are *O. quinquemaculatus* LeConte, *O. balli* Campbell, *O. bierigi* Campbell, *O. lateralis* Gravenhorst, *O. lawrencei*

Campbell, *O. mexicanus* Fauvel, *O. rufipennis* LeConte, and *O. stygicus* (Hanley & Goodrich 1995).

Few collection records for species of *Oxyporus* include fungal hosts for larvae. From the host data available for the genus, larvae appear to be specialized on one or two species of related fungi within a small portion of the subset of preferences exhibited by adults. Large numbers of larvae of *O. japonicus* were collected from only one species of fungus, which further supports this pattern. The reasons for this apparent host specificity are unknown; however, Hanley & Goodrich (1995) hypothesized that mushrooms within an adult's subset of fungal preferences that exhibit fleshy-fibrous context allow more efficient internal feeding while being fibrous enough to maintain overall shape of the mushroom.

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